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MICROCOMPUTER SIMULATION OF A CLOTHING DISTRIBUTION CENTRE

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ABSTRACT

A computerised simulation model of the Distribution Centre of a sizeable clothing company is developed. This article reviews the model constructed, and the estimation of its parameters, introducing the simulation language SLAM II as a modelling framework. The flexibility of the computer model and its usefulness as a decision support tool, are highlighted.

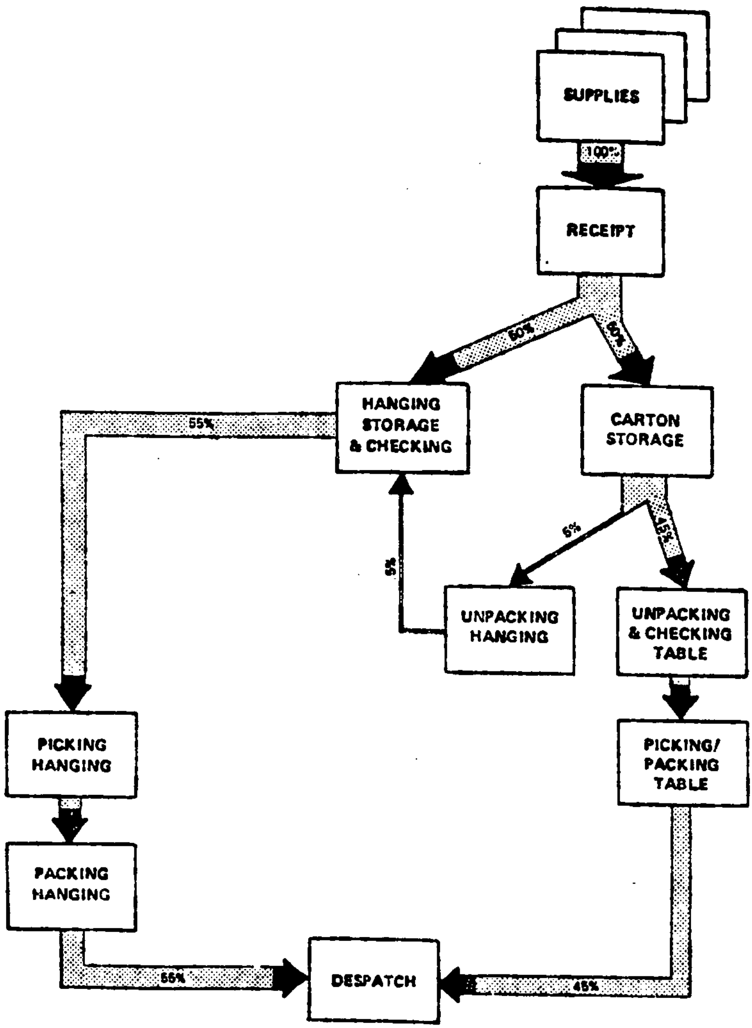
1. INTRODUCTION AND PROBLEM SETTING

The Distribution Centre concerned is the focal point and regulator of merchandise movement in the company, handling seven to eight million units of new merchandise each year. The accumulation and distribution process is a stochastic, and highly dynamic one; until now, no model embodying these two features has existed. This process is represented in outline in Figure 1.

Merchandise is received in bundles of STYLES; approximately 50% is loose hanging and 50% table merchandise (arriving in cartons).

* Work done while the author was a graduate student in the Department.

FIGURE 1. THE WAREHOUSE PROCESS



Hanging and table goods follow completely separate, though parallel, paths through the centre. The garments pass through quantity and quality checks and a number of styles accummulates, forming a shipment. Shipments are allocated among the various branches* (picked), packed in cartons, and released from the centre (despatched).

Because of the critical nature of this part of the retailing process, throughput time, i.e. time interval from receipt to despatch of merchandise, is of great concern to the company and many of the suggested alterations to the current system are concerned with improving (reducing) this throughput time.

2.1 Model orientation

In keeping with the concept of a Unified Modelling Framework, provided by Pritsker in his simulation language SLAM II [1], the system is modelled almost wholly as a discrete change system within a combined process-event orientation.

The process orientation of the model means that extensive use is made of the SLAM network structure. This is, in effect, a specialised flow chart; symbols of which represent elements in standard processes like queues, resources and activities. Each node or branch of the flow chart translates into a line of SLAM code.

The event orientation is a result of the modeller's need to define and implement non-standard events or changes to the system; these are coded in FORTRAN subroutines.

A diagrammatic summary representation of the model is presented in Figure 2. SLAM symbols have been used to give the reader an introduction to the use of the network facility described above.

* There are 280 company branches, classified as Extra Large, Large, Medium or Small, according to branch turnover. Often, in the case of Small or Medium branches, there is insufficient table merchandise to fill a packing carton; the garments are sealed in plastic bags and enclosed in the cartons of the subsequent hanging shipment.

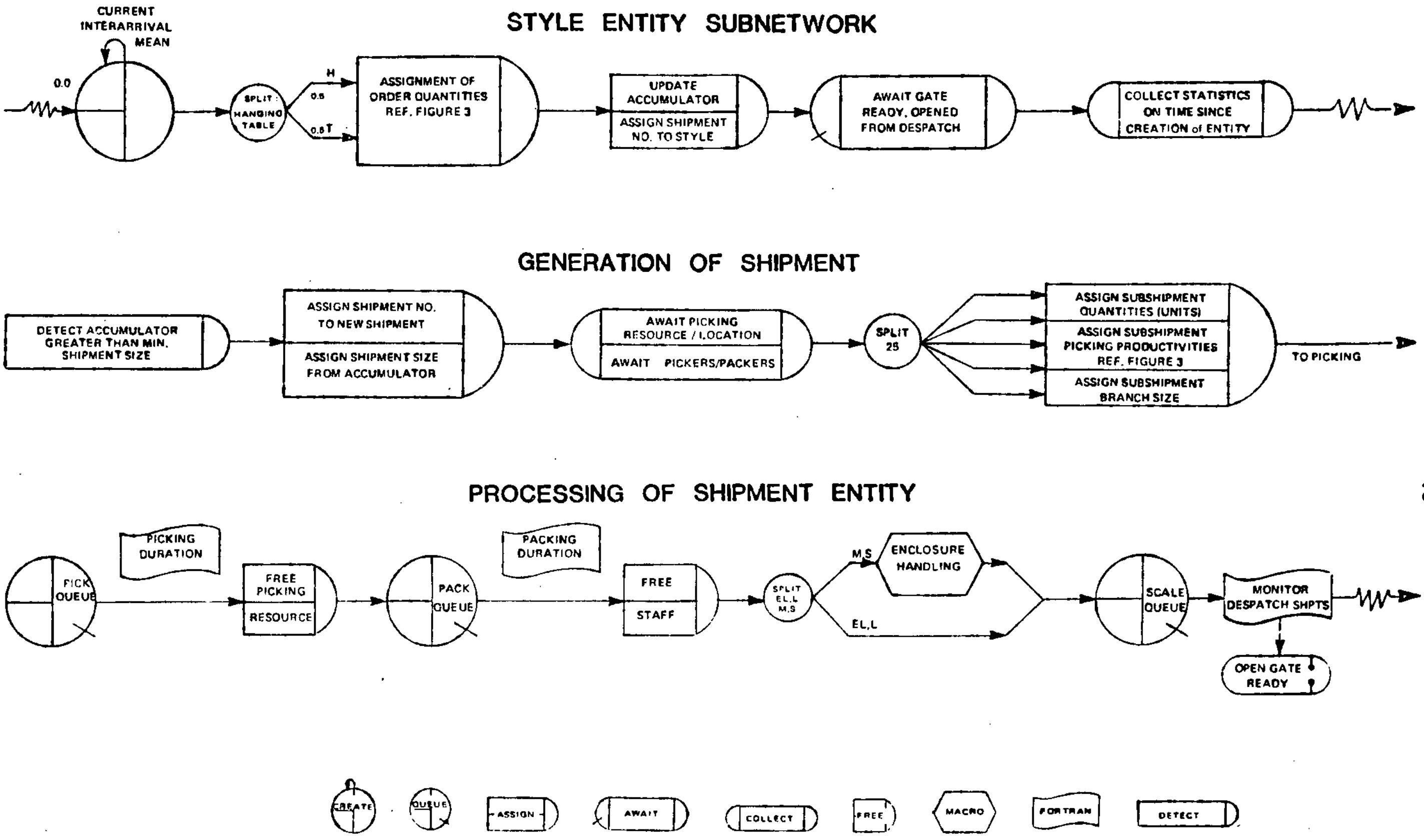


FIG 2. MODEL SUMMARY

2.2 The model entities

Pritsker defines these as the objects within the boundaries of a discrete system; I choose to use this term in a narrower sense viz to mean those objects operated upon; entering the system, being processed, and exiting from the system.

The choice of model entity is a critical one, and is, to a large extent, determined by the objective of the simulation, i.e. in which characteristic of the system the modeller is ultimately interested.

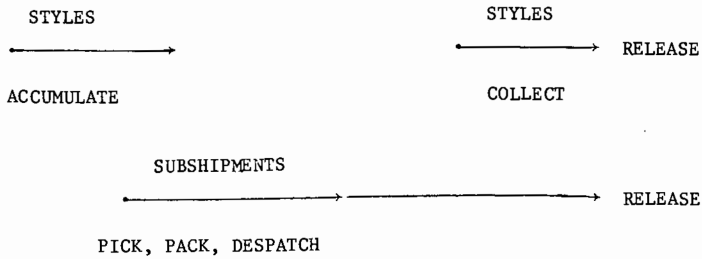
Now, garments arrive in groups of styles, so the most natural entity to deal with would seem to be a style entity, the time interval from its arrival to its release from the system would be traced.

The problem with this approach is that from picking onwards, the styles become fragmented and difficult to identify. In fact, from picking onwards, the most natural entity to deal with is a branch or some division of the shipment. This duality in the model further complicates an already complex scenario, but can be dealt with.

The solution: have two different types of model entities - initially a style, then a subshipment (a subshipment is 4% of a shipment; this figure was chosen because, in general, 4% of a shipment must finish one activity e.g. picking before the next activity can begin).

Style entities are created, assigned to a shipment number and accumulated. When sufficient units have accumulated, a shipment entity with that number is generated and passes through the picking, packing and despatch processes, while its constituent style entities remain inactive. These style entities are released when their shipment entity completes processing and statistics are collected on the time interval since their creation.

To summarise:



2.3 Outline of the Model

As indicated previously, the main elements of the model logic is given (in a pseudo-SLAM diagrammatic form) in Figure 2.

Arrivals of batches of goods of a single style are generated according to a Poisson process. As each batch is generated, it is assigned as being "hanging goods" or "table merchandise" by a random selection. (In fact, from this point onwards, the model is essentially duplicated to treat hanging and table goods separately according to a slightly different logic.) The size of the batch is drawn from a pre-specified probability distribution. The flow of each batch through the network is controlled by two gates. Each style batch passes through the first gate, and batches are accumulated until there is sufficient to allow the preparation of a shipment of goods to branches. When this occurs, the first gate closes (to block the processing of further styles until the current shipment is despatched). Once preparation of the shipment is complete, a second gate is opened to allow the batches making up this shipment to leave the system. Statistics are collected on the time from arrival as a style batch to departure in the shipment. Finally, the second gate is again closed, and the first opened, to allow another shipment to be built up.

A major portion of the model is concerned with representing the preparation of a shipment (viz. the second two rows shown in Figure 2). A new shipment is generated whenever a sufficient quantity of styles have accumulated. Preparation of the shipment is delayed until sufficient human and physical (i.e. racks, hanging rails etc.) resources are available; a further delay models the fact that the picking and packing of a shipment will generally start in the morning.

The basic shipment entity is split into 25 separate entities, representing different categories of store, taking different proportions of the total shipment quantity. Times required to pick out the required items from style batches to make a shipment entity are obtained to depend upon the size of the shipment. Once prepared, the shipment is queued for packing and for despatching.

In the case of smaller categories of branch, a further complication has to be modelled. Shipments of table of hanging goods are not despatched separately (even though up to this point, the shipments have been modelled independently). For these smaller branches, shipments of table goods are sealed into enclosures, which are incorporated into the next shipment of hanging goods. This complication necessitates additional bookkeeping, but does not fundamentally change the model logic.

To a large extent the above logic is easily expressed in the network modelling framework of SLAM, and could thus be relatively quickly coded and debugged. In a few instances, the logic did however require the writing of a few short FORTRAN subroutines (see Section 4).

3. PARAMETER ESTIMATION

That the model should represent reality, is of paramount importance, hence the large proportion of model development time spent in the field, observing actual processing rates and durations, and then applying various techniques to obtain efficient summary statistics.

Figure 3 summarises the results of this phase.

Explanatory appendix to Figure 3

- These parameterisations were all selected bearing in mind that in a situation such as this, in which each process is but a part of the whole, it is satisfactory to achieve representations giving a general idea of trends and variability.
- The program allows user modification of the interarrival mean (see Section 4).

FIGURE 3: DATA SUMMARY

OPERATION/PROCESS	QUANTITIES REQUIRED	FIGURES ACCEPTED
RECEIPTS	Interarrival times	Exponential (umean)
	Order quantities - Hanging	Discrete Distribution (Observed histogram: assumed uniform over class intervals)
	Order quantities - Table	
PICKING	Picking productivity - Hanging	Normal (Different means, variances - each branch size group)
	Picking productivity - Table	Normal "
PACKING	Time elapsed start to finish	Linear regression equations
	- Hanging	$(10.6 + 0.08\ x_1 + 3.19\ x_2)$/PACKERS x, x_1 = units
	- Table	$(54.6 + 0.05\ x)$/PACKERS x_2 = enclosures
SEALING	Time per sub-shipment	1.25 minutes x number of branches
DESPATCH	Time per sub-shipment	0.5 minutes x number of cartons
	Number of cartons (Y) - Hanging	Y = Units/39.47
	- Table	Y = Units/69.03

- An attempt was made to fit a Generalised Linear Model to picking productivities with explanatory variables:

  (1) merchandise type,

  (2) branch size being picked, and

  (3) shipment size.

  These variables were suggested by Distribution Centre supervisors, but failed to provide a satisfactory relationship; subsequently, picking productivities were found, in general to conform to normality. This was the level on which investigation into the actual situation was conducted.

4. THE WORKING MODEL

Length : 530 lines (SLAM)
300 lines (FORTRAN)

Machine : IBM PC XT (640 K)

Run Time : Approximately 20 minutes for simulated time period of five weeks. (This is significantly reduced to less than 10 minutes when the program is run on a PC with an 8087 chip.)

Almost half of the FORTRAN code is made up of subroutine INTLC, an initialisation procedure which allows the user to input the following system parameters:

(1) mean interarrival rate for each day of the run

(2) minimum hanging and table shipment sizes

(3) numbers of pickers/packers

(4) percentage normal merchandise (i.e. merchandise moving directly through the system; in general, a fixed proportion of incoming merchandise is held for a period of up to four weeks before being allowed to accumulate for a shipment).

Parameters 1, 2 and 4 determine, in effect, the rate at which the Distribution Centre operates, and the model is fairly sensitive to significant changes in their values. A low interarrival mean, coupled with a high Normal percentage, results in a build-up of merchandise, and a substantial demand for resources (equipment and staff) in the processing portion of the model. This is made evident by the long entity wait times in the File Statistics of the SLAM Summary Report obtained at the end of each run. Larger shipments relieve this build-up somewhat, but shipment size is limited by resource availability. Greater resource availability is thus implemented by incrementing the minimum shipment size (parameter 2).

The SLAM Summary Report, provided at the end of each simulation run, gives statistics on entity waits, resource utilisation and user requested quantities. In this case, statistics on the time intervals from style entity arrival to departure, are collected and histograms produced.

Figure 4 tabulates some results thus obtained, altering simulation experimental conditions. These results are compared with some average weekly throughput times from the Distribution Centre over the months of September/October 1985. (Note that the figures collected in the centre are for hanging and table merchandise combined.)

FIG 4 : MEAN THROUGHPUT TIMES (DAYS) : NORMAL MERCHANDISE

SIMULATED			OBSERVED
HANGING	TABLE	ALL	
4.1	6.3	5.2	4.9
5.5	7.1	6.3	6.1
6.3	7.0	6.7	6.8
6.0	6.6	6.3	6.2

Clearly, the model results are highly consistent with those observed, indicating that we have realistic representation of the Distribution Centre operation, one which can confidently be used to test potential changes and proposed alterations to the system.

What are the changes envisaged? Briefly, these relate to the company's projected growth and thus merchandise processed and facilities/equipment available for this processing. Various projected scenarios may be implemented, and potential needs or drawbacks of the current system highlighted. Suggested solutions to problems that arise, which do not require major structural changes (e.g. alteration of resource and labour availability, and even of processing rates and durations) may be implemented with relative ease. These and more involved proposals may necessitate some editing of the source code, which, depending on the extent of the alteration, will require varying amounts of programming time.

5. CONCLUSIONS

Simulation Modelling is a lengthy and complex procedure; Pritsker describes it an as art. In this respect, SLAM is far more than simply a high level computer language for simulation programming. SLAM provides the modeller with an organised methodology, encouraging the extension of a simpler, primary solution to a more complex and accurate final solution.

The aspect of Simulation Modelling which makes it at the same time interesting, challenging and different is, of course, its dynamic nature. The point of this article has been to show that this feature, coupled with thorough investigation of the real system and appropriate statistical parametrisations, results in a model which can be used in an almost unlimited number of ways, to provide information without the slightest interference in the real-life situation.

In today's world, where costs are exhorbitant, and failure can be disastrous, simulation can be an invaluable tool and guideline in the making of important decisions.

REFERENCES

[1] A.A.B. PRITSKER, *Introduction to Simulation and Slam II*, (2nd Ed.), Wiley (1984).